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GB 2154504 A US 4339295 A

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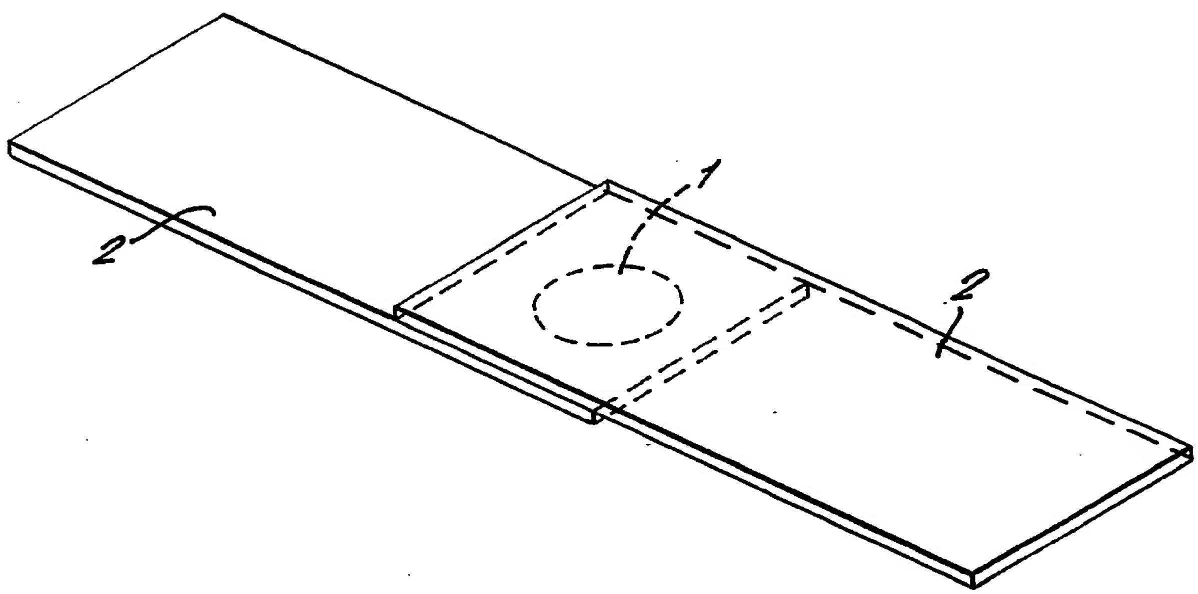
(54) Joining polymer-containing materials

(57) A method of joining polymer-containing materials (2) is characterised by providing a microwave excitable conductive polymer material (1) in the region to be joined, exposing the material to microwave radiation to heat it and thereby soften or melt polymers (2) in that region and then allowing cooling so that the softened/melted polymers resolidify together and bond the materials in that region.

FIG. 1.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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FIG. 1.

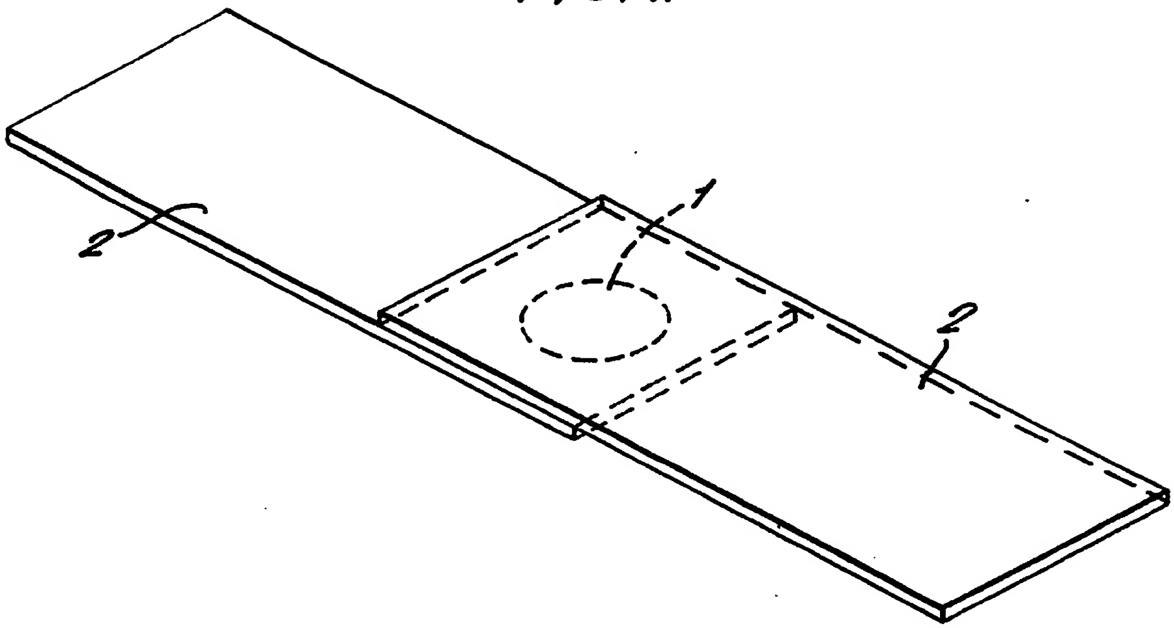
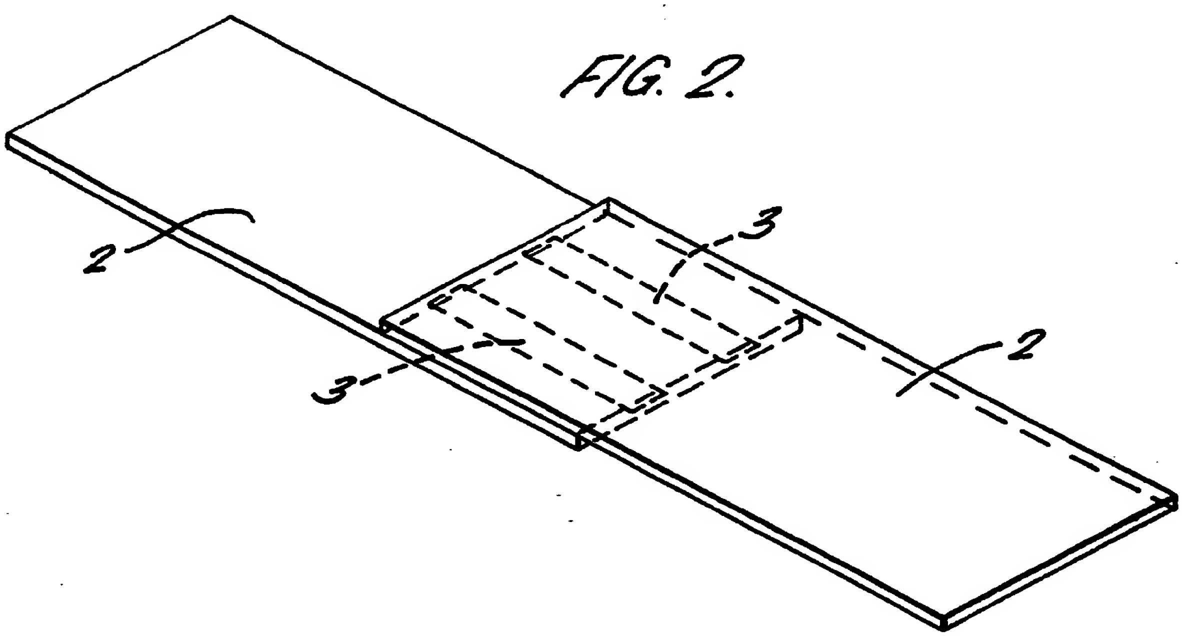


FIG. 2.



JOINING POLYMER-CONTAINING MATERIALS

The invention relates to a novel method of joining materials, particularly polymer-containing materials such as plastics materials and ceramic polymer composites. In particular it relates to a method of joining such materials which employs microwave excitable conductive polymer materials.

Conventional methods for joining together plastics materials include bonding using an adhesive such as an epoxy resin and "welding". Welding has been carried out by placing a conductive metal, such as copper, between two pieces of plastics material to be joined. A current is then passed through the copper to heat it resistively. The heating is continued until the plastics materials near the copper soften or melt. Then on subsequent cooling and resolidifying the softened or melted plastics materials adjacent each other bond together. The copper may be heated sufficiently for it to melt and flow out of the joint area so that it can be collected for reuse but some copper may remain. This method has the disadvantage that it may take a long time and a large current to produce the necessary heating. Also copper remaining in the joint does not itself contribute to the bonding. Copper may also weaken the joint over time due to corrosion.

The present invention provides a novel method of joining plastics materials by "welding".

In accordance with the present invention there is provided a method of joining polymer-containing materials characterised by providing a microwave excitable conductive polymer material in the region

to be joined, exposing that material to microwave radiation to heat it and thereby soften or melt polymers in that region and then allowing to cool so that the softened/melted polymers resolidify together and bond the materials in that region.

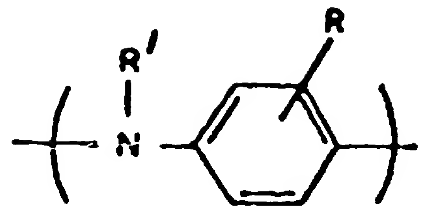
The polymer-containing materials are bonded by the "welding" together of polymers in the region of the joint.

Any conductive polymer material which is excitable by either the electric vector or the magnetic vector of electromagnetic radiation in the microwave region may be employed in the invention. As these conductive materials are polymeric in nature they contribute to the bonding together of the polymer-containing materials. Conductive polymers which can be excited at the frequency of operation of domestic microwave ovens which is 2.45 GHz are preferred for use in the invention for reasons of convenience.

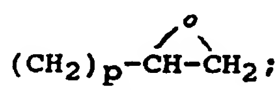
Conductive polymers which may be employed in the invention include polypyrrole and substituted polypyrrole, polythiophene and substituted polythiophene, polyaniline and substituted polyaniline, aniline copolymer, polyphthalocyanine, polyphenylene, poly(isothianaphthene), polysilanes and polyphenylvinylene.

Examples of substituted polypyrroles which may be used in the invention are those which are disclosed in EP-A-0253595. Examples of substituted polythiophenes which may be used in the invention are disclosed in EP-A-0253594.

Examples of substituted polyanilines which may be used in the present invention are those which comprise repeating units of the general formula:

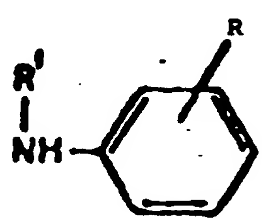


where R is in the ortho- or meta-position and is $-(CH_2)_mO(CHR''CH_2)_nOR'''$ where m is 0 or an integer of from 1 to 6, n is an integer of from 1 to 6, R" is a hydrogen atom or a methyl group and R"' is an alkyl group containing from 1 to 6 carbon atoms, or the group



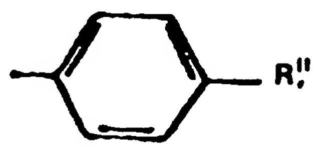
where p is 0 or an integer of from 1 to 6, and R' is hydrogen, C_{1-6} alkyl or aryl, and counterions of the formula X, where X is Cl^-, Br^-, $SO_4^{=}$, BF_4^-, PF_6^-, $H_2PO_3^-$, $H_2PO_4^-$, arylsulphonate, arenedicarboxylate, arenecarboxylate, polystyrene sulphonate, polyacrylate, alkylsulphonate, vinylsulphonate, vinylbenzene sulphonate, cellulose sulphonate, cellulose sulphate or a perfluorinated polyanion.

Examples of aniline copolymers which may be used in the present invention are the copolymers of an aniline monomer of the general formula:



where R is in the ortho- or meta- position and is hydrogen, C_{1-18} alkyl, C_{1-6} alkoxy, amino,

chloro, bromo, sulpho, carboxy, hydroxy, sulphonyl, vinyl, or the group



where R" is alkyl or aryl; and

R' is hydrogen, C_{1-6} alkyl or aryl; with another aniline monomer of formula I as defined above, the copolymer including counterions X where X is as defined above.

The conductive polymer may conveniently be provided in the form of powder or granules. These which may be used include not only simple powder or granules but also inorganic powdery or granular materials which have been coated with conductive polymeric material such as those described in EP-A-0298746.

Alternatively, the conductive polymer may be provided in the form of a tape, for example a tape formed of a plastics material which has been impregnated with the conductive polymer. Plastics materials from which such tapes may be formed include polyethylene, polyester, polypropylene, polyurethane, polyvinylchloride, polyacrylonitrate/butadiene/styrene, polycarbonate or polyamide. Two or more small pieces of tape will heat and melt more quickly than one large piece.

Techniques for coating inorganic granular or powdery materials with conductive polymers by polymerisation of the relevant monomer in situ both chemically and electrochemically are described in EP-A-0290746. The chemical techniques described in this document are also useful for impregnating with

conductive polymers tapes of plastics materials which are themselves inherently non-conducting. Tapes which are to some extent conductive may also be impregnated electrochemically.

The polymer-containing materials which may be joined by the present invention include ceramic polymer composites as well as simple plastics materials. Such polymer-containing materials may comprise for example polycarbonate, polyamide, polyethylene, polypropylene or polyetheretherketone.

The irradiation will conveniently be carried out at a microwave frequency of 2.45 GHz as this is the legally allowed frequency for domestic microwave ovens although other frequencies may be employed. The irradiation will be carried out until the heat provided is sufficient to soften or melt the polymer of the polymer-containing material. The conductive polymer may also itself melt. Adequate heating in most cases is provided by irradiation at a power in the range 100W to 2000W for a time period of 10 milliseconds to 300 seconds.

The present invention includes plastics materials that have been joined by the method of the invention.

The invention relates generally to use of a microwave excitable conductive polymer material in the joining of polymer-containing materials.

The invention will now be illustrated by the following examples

Example 1

A small quantity (100mg) of poly(pyrrole)p-toluenesulphonate powder (1), a conductive polymer, was placed between two pieces (about 1mm x 35mm x 150mm) of overlapped polycarbonate (2) as shown in Figure 1. The area of overlap was about 35mm x

30mm. This overlapped structure was then placed on the turntable of a domestic microwave oven which operates at a frequency of 2.45 GHz. Pyrophyllite, which is a ceramic material which does not absorb at the microwave frequency used, was placed on top of the overlap to weight it and keep it in position. The pressure exerted by the pyrophyllite on the area of overlap was 0.015 N/mm^2. The structure was then irradiated at a power of 500W for a time of 180 seconds. This excited the conducting polymer powder and heated it sufficiently to melt the polycarbonate in the region of the powder.

After cooling the structure was examined and the two pieces of polycarbonate were found to have welded together in the region of the overlap to produce a strong bond which incorporated the poly(pyrrole)p-toluenesulphonate.

<u>Examples 2 and 3</u>

Example 1 was repeated using different conductive polymers. The polymers used and conditions employed are shown in Table 1.

In all cases a strong bond was found to have been formed.

<u>Examples 4 to 10</u>

These were carried out in the same manner as Example 1 except that conducting polymer tape was employed in place of the conducting powder. The tapes employed consisted of a supporting plastics material impregnated with the conducting polymer. Two tapes (3) about 0.5cm wide were used in each case and positioned as shown in Figure 2. The nature of the tapes and plastics material used and the

conditions employed in the Examples are shown in Table 1.

Again the irradiation was carried out until the plastics material had softened or melted in the region of the tapes due to the heat produced by excitation of the conducting polymer. After cooling the structure was examined and in all cases a strong bond was found to have been formed.

Table 1

Example No.	Substrate to be welded	Conductive polymer	time to weld/ seconds	Pressure applied to the joint $/N/mm^2$
1.	Polycarbonate	poly(pyrrole) p-toluenesulphonate (p)	180	0.015
2.	Polycarbonate	Poly(aniline) p-toluenesulphonate (p)	180	0.015
3.	Polycarbonate	Poly(aniline) coated talc (p)	120	0.015
4.	Polycarbonate	A (t)	10	0.015
5.	Nylon 6,6	B (t)	10	0.015
6.	Polypropylene	B (t)	5	0.015
7.	Polypropylene	A (t)	10	0.015
8.	Polyethylene	B (t)	15	0.03

Note p = powder t = tape

A: non-woven polyester tape which has been impregnated with poly(pyrrole)

B: microporous polyethylene (Scimat) tape which has been impregnated with poly(pyrrole)

CLAIMS:

1. A method of joining polymer-containing materials characterised by providing a microwave excitable conductive polymer material in the region to be joined, exposing that material to microwave radiation to heat it and thereby soften or melt polymers in that region and then allowing to cool so that the softened/melted polymers resolidify together and bond the materials in that region.

2. A method as claimed in claim 1 characterised in that the conductive polymer is polypyrrole or substituted polypyrrole, polythiophene or substituted polythiophene, polyaniline or substituted polyaniline, aniline copolymer, polyphthalocyanine, polyphenylene, poly(isothianaphthene), polysilane or polyphenylvinylene.

3. A method as claimed in claim 1 or claim 2 characterised in that the conductive polymer is provided in the form of powder or granules.

4. A method as claimed in claim 3 characterised in that the powder comprises an inorganic material coated with the conductive polymer.

5. A method as claimed in claim 1 or claim 2 characterised in that the conductive polymer is provided in the form of a tape.

6. A method as claimed in claim 5 characterised in that the tape is formed of a plastics material which has been impregnated with the conductive polymer.

7. A method as claimed in claim 6 characterised in

that the tape comprises polyethylene, polyester, polypropylene, polyurethane, polyvinylchloride, polyacrylonitrate/butadiene/styrene, polycarbonate or polyamide.

8. A method as claimed in any one of claims 1 to 7 characterised in that the polymer-containing materials to be joined are plastics materials or ceramic polymer composites.

9. A method as claimed in any one of claims 1 to 8 characterised in that the polymer-containing materials to be joined comprise polycarbonate, polyamide, polyethylene, polypropylene or polyetheretherketone.

10. A method as claimed in any one of claims 1 to 9 characterised in that the microwave irradiation has a frequency of 2.45 GHz.

11. A method as claimed in any one of claims 1 to 10 characterised in that the microwave radiation is provided at a power in the range 100W to 2000W for a time period of 10 milliseconds to 300 seconds.

12. Plastics materials that have been joined by the method of any one of claims 1 to 11.

13. Use of a microwave excitable conductive polymer material in the joining of polymer-containing materials.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

9125814.5

..elevant Technical fields

(i) UK Cl (Edition K) B5K, H5H (HMP)

(ii) Int Cl (Edition 5) B29C

Search Examiner

MIKE HENDERSON

Databases (see over)

(i) UK Patent Office

(ii)

ONLINE DATABASE: WPI

Date of Search

13 MARCH 1992

Documents considered relevant following a search in respect of claims 1-13

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB A 2154504 (MAGNETRONICS LIMITED UK) Whole specification relevant	1,8,12,13
X	US 4339295 (BORETOS ET AL) Whole specification relevant	1,8,12,13

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Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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